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doned lake bluffs in suggesting that within historical times the water supply of Sistan was greater than now. One or two thousand, or even five hundred years ago, this region, which is now so poverty-stricken, was most prosperous. According to Lord Curzon, the number of ruins in Sistan is probably greater than in any equal area in any part of the world. The former population must have been far more dense, and at the same time more prosperous than that of to-day. It seems probable that the decrease in the water supply, on the one hand, and the impoverishment and diminution of the people on the other, bear the geographic relation of cause and effect.

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## THE TERRESTRIAL MAGNETIC WORK OF THE UNITED STATES COAST AND GEODETIC SURVEY.

BY

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A retrospective glance at the beginnings and the growth of knowledge in terrestrial magnetism will heighten our appreciation of the important advancements that are being made in this branch of geophysics by the United States Coast and Geodetic Survey. Since, as a system of organized knowledge, terrestrial magnetism presupposes and requires centuries of observations, it has not long been entered in the hierarchy of the physical sciences, but has nevertheless made gratifying progress under the exceptional administration that has been bestowed upon the subject in the magnetic survey of the United States.

In comparison with the age of many of the other earth-sciences, it is singular to find that, even if it be admitted that a knowledge of the misdirection of the magnetic needle from the true north and south direction existed more than four centuries ago, it was reserved to Christopher Columbus to discover, during his voyage of discovery to the New World, that the declination was not everywhere the same, but that in one part of the Atlantic Ocean the compass needle pointed to the east of north, and in another part to the west of north; and that it was no longer ago than the year 1634 when Gellibrand, a Professor of Mathematics at Gresham College, in England, found that the declination at any certain place does not remain the same, but suffers a perpetual fluctuation with the course of time. The world waited for a realization that the magnetic needle, when freely

suspended, inclines or dips below the horizon, until Norman, a practical seaman and instrument-maker, made his experiments in the year 1576, and, besides discovering the magnetic inclination, published the surmise that the magnetic directing-force has its seat within the earth, and not in the heavens, as had been previously supposed. Gauss, of Göttingen, established the substantial truth of this surmise by analytical methods with the aid of accumulated observations of the values of the terrestrial magnetic elements, and in 1838 announced that the earth's permanent magnetism is derived almost entirely from sources within its own crust. This eminent mathematician and astronomer was among the first of those profound and subtle thinkers in terrestrial magnetism to go beyond the Empiricist School, in which the ruling idea was the treatment by arrangement of great masses of observations, and to pass on into the field now characterized by the writings of Dr. Bauer as published in his *International Journal of Terrestrial Magnetism and Atmospheric Electricity*, in which the work of the mind becomes a preponderating element in the constitution of the knowledge of the causes and manifestations of the earth's magnetic state.

About the year 1840 the discussion of observations of the direction of the magnetic needle and of the intensity of the earth's magnetic force became a feature of the work of the United States Coast Survey. The late Professor Schott had charge of these investigations for nearly half a century, and under his guidance a study was made of the diurnal variation of the declination in its various phases for different localities in North America. The secular change of the directional elements of the magnetic needle also received his attention, and he made a comprehensive and systematic collection of the magnetic observations taken in the United States and adjacent countries to serve the Survey as a basis for the solution of problems relating to the secular change of the earth's magnetism. Acting under the enlightened advice of Dr. Henry Pritchett, Congress increased the appropriation of money largely above what had previously been made for magnetic work in the Coast and Geodetic Survey, and so, in 1899, made it practicable to organize a Division of Terrestrial Magnetism and to secure the able leadership of Dr. Bauer in the conduct of the magnetic survey of the United States. This organization has established magnetic observatories in the eastern and western parts of the United States, in Alaska, in Hawaii, and in Porto Rico; has collected together a large material equipment; and is now carrying on its work under highly improved and efficient methods. At the end of the first five

years of its existence, its operations in the United States and the countries under the jurisdiction of the United States have resulted in the survey of an area equal to one-third of that of Europe, and in making of observations for magnetic declination, inclination, and intensity at 1,636 stations, including a large number which had been previously occupied for magnetic observations and which were reoccupied with the object of providing data for the investigation of the secular change.

The results obtained by the Survey, supplemented by the results of surveys made by some of the State Governments, together with other information, enabled the U. S. Coast and Geodetic Survey to construct a chart depicting the lines of equal magnetic declination and of equal annual change in the United States for the epoch 1902. These lines also extend through Mexico and the Gulf of Mexico, and through Cuba, Jamaica, and other parts of the West Indies. One of the distinctive features of this chart is a system of "lines of equal annual change." The rate of change of the lines of equal magnetic declination being shown graphically, the future charts of this type will show *the change of the annual change*, which will be useful in the study of the secular change. Besides its useful bearing upon multifarious practical affairs of every-day life, and its value to students of geology and other branches of geophysics, the chart serves the purpose of navigators in ascertaining the correct direction of the magnetic meridian along the Atlantic and Pacific coasts of the United States and in the Gulf of Mexico and the Great Lakes. Future editions of this publication will be enhanced in value by the multiplying observations that will become available as the magnetic survey proceeds, and also by the recent commendable inauguration of a system of terrestrial magnetic observations at sea by the vessels of the Coast and Geodetic Survey.

When the extent of the magnetic observations of the Coast and Geodetic Survey is considered in connection with the intended magnetic survey of the North Pacific, which has been provided for under the direction of Dr. Bauer by the Carnegie Institution of Washington, it will appear that the terrestrial magnetic surveying work of the United States is already assured to embrace nearly one-fourth of the earth's surface, and that it may, with the possible extension by the Carnegie Institution of the surveying work to the other great oceans, ultimately cover more than three-fourths of the earth's surface.